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NDT MEASUREMENTS OF CHROMIUM PLATE THICKNESS ON SMALL CALIBER G--ETC(U)
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NDT MEASUREMENTS OF CHROMIUM PLATE THICKNESS ON SMALL CALIBER GUN BARREL BORES.

(9) Technical rept.,

by

(10) JOSEPH M. BISH

(11) MAY 1978

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ENGINEERING DIRECTORATE

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    3. Non-Destructive Testing (NDT)
    4. Eddy Current Testing
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

Chromium-plate thicknesses of gun barrel bores are necessarily assumed since the air gauges used simply provide differences in bore-size readings before and after plating. The only means available to accurately determine plating thickness, including concentricity, is to use destructive methods to examine microspecimens representing cross sections of the gun barrel. The objective of this project was to make use of improved nondestructive testing methods to measure chromium plate thicknesses in small caliber gun barrels.

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20. ABSTRACT (cont)

Evaluation of improved NDT inspection methods resulted in the selection of two instruments using eddy current testing technology. The instruments, selected for comparative evaluation, were the Nortec NDT-10 and the Dermitron Thickness Tester. The Nortec NDT-10 Eddy Current Tester, used to measure 5.56mm gun tubes, could not be calibrated due to repeated malfunctions of the instrument; consequently, no meaningful data could be recorded. The Dermitron Thickness Tester, used to measure 7.62mm gun tubes, was calibrated and chromium thickness measurements were taken of an M-60 gun barrel. These measurements showed good correlation with actual thickness measurements of metallographic specimens taken of the gun barrel.

The accuracy and usefulness of the Dermitron would be improved by more frequent calibration and reduction of calibration time by using automated recording/printout methods. Recommendations to expand the use of eddy current testing methods for the determination of chromium plate thicknesses in small caliber gun barrels have been made.

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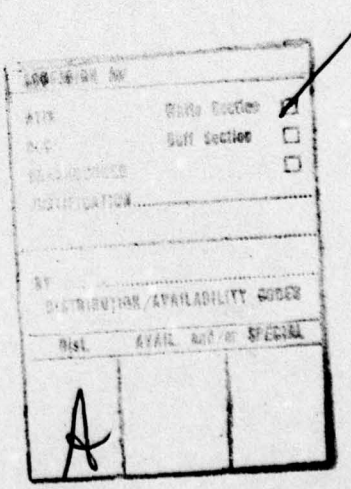


ILLUSTRATIONS

INTRODUCTION

The bores of small arms gun barrels are chromium plated when it is necessary to withstand the erosive effects of severe firing schedules. Since the accuracy of a gun barrel is somewhat degraded by the electropolishing and electroplating operations, it is imperative that the plating be deposited as uniformly as possible.

When chromium-plate thicknesses are measured during electroplating operations, the uniformity of the chromium layer (including the concentricity of the deposit) is necessarily assumed. This is attributed to the air gauges used which are not able to measure specific chromium thicknesses but simply provide differences in bore-size readings before and after plating. Thus, for lack of a more accurate thickness measuring technique, this procedure is used for in-process control when gun barrels are chromium plated. The only means available to accurately determine plating thickness, including concentricity, is to use destructive methods to examine microspecimens representing cross sections of the gun barrel.

The objective of this project was to make use of improved nondestructive testing (NDT) methods to measure chromium plate thicknesses in small caliber, e.g. 5.56mm and 7.62mm, steel gun barrels. The NDT method to be used must enable a quality assurance inspector to measure the chromium plate thickness at any point in a gun barrel approximately 24 - 30 ins. long. Instrumentation should be sufficiently rugged for rapid inspection of gun barrels in a production environment and accurate enough to determine chromium thickness with one to a maximum of three measurements at any point. Evaluation of improved NDT inspection methods resulted in the selection of instrumentation using eddy current testing technology.

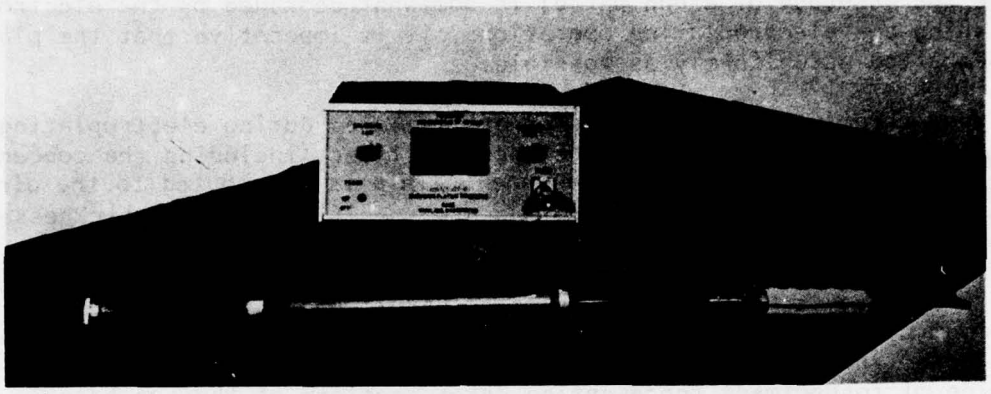
Two instruments were selected for comparative evaluations. One was developed by the Nortec Corporation to measure 5.56mm gun tubes and the other was manufactured by Unit Process Assemblies, Inc. to measure 7.62mm gun tubes.

Equipment

A. Nortec Eddy Current Tester, NDT-10*

The NDT-10 (Fig. 1a) is a direct reading, phase sensitive instrument using 2 easily-adjusted front panel controls to calibrate digital readout in mils of plating thickness. The instrument, 117 v AC, has solid state circuitry, weighs 15-lbs and its dimensions are 6"h x 16"w x 12"d. It was designed to measure chromium thicknesses from 0.0 to 5.0 mils. The probe used with the NDT-10 is a 500 KC eddy-current probe mounted on a 27-in. wand, and its sensing coil enables the operator to measure plating thickness of one specific land as the probe is passed over the land. The probe body (Fig. 1b) is made of an epoxy with the sensing coil

*Developed under Contract No. DAAF03-72-C-0085 by the Nortec Corporation, Richland, WA 99352



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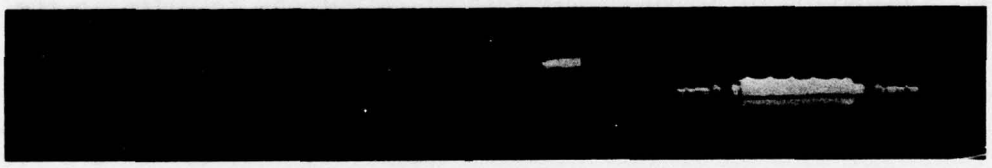

b.

Figure 1. a. Nortec NDT-10 Eddy Current Tester with Probe Inserted in 5.56mm Gun Barrel.

b. Probe for the Nortec NDT-10 Eddy Current Tester

embedded in the epoxy. A felt pad inserted under the probe body (opposite the sensing coil) is used to facilitate a smooth even travel throughout the length of the gun barrel. A 2-in. flex section is inserted between the probe body and the wand to minimize pressure changes on the coil and stress on the probe body should misalignment of the wand occur.

B. Dermitron Thickness Tester*

This apparatus consists of a standard Dermitron Basic Unit, Model D-2, eddy-current thickness gauge equipped with a probe-system designed to measure 7.62mm gun tubes having chromium thicknesses from 0.0 to 5.44 mils. The basic unit is 11"h x 17"w x 9"d. The instrument, 115 v AC, is equipped with a carrying handle and weighs 26 lbs. The probe is connected to the "C" receptacle on the front panel of the basic unit (Fig. 2).

The measuring probe consists of a stainless steel tube linked to a measuring-head by means of a short teflon section (Fig. 3). The measuring-head contains the sensing-element which is held with a spring loaded element-holder. The face of the element-holder which rides along the land is a hard flame-sprayed surface. The guide and other bearing surfaces are similarly hardened. The sensing-element is fixed in its holder to prevent contact with the land, thereby preventing any wear on the sensing-element.

Although the element-holder is spring-loaded, it is recessed to eliminate interference during entry of the probe-head into the gun barrel. After entry, the probe-head can be moved continuously throughout the barrel so that the sensing-element can measure the chromium thickness at any point on the surface of any particular land.

Wire leads from the probe coil pass through the teflon section to a shielded twin-lead cable which runs through the tube. This cable is fastened within the handle of the probe and extends to the connector.

The purpose of the teflon section is to allow a floating action for the measuring-head, so that the head will remain properly oriented within the bore without being adversely affected by excessive lateral pressures exerted by the operator.

The wand is graduated at 1-in. intervals, enabling the operator to easily determine the position of the sensing-element along the land-surface. Figure 4 shows the probe being passed through a gun barrel.

Procedure

A. Nortec NDT-10 Measurements of 5.56mm Gun Barrels

* Manufactured by Unit Process Assemblies, Inc., P.O. Box 1011, 53-15 37th Avenue, Woodside, NY 11377

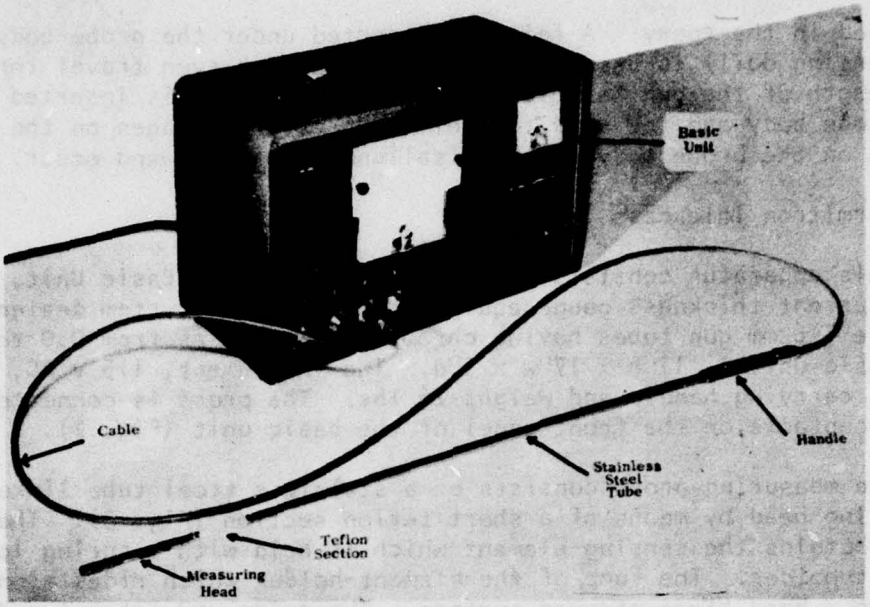

Figure 2. Dermitron Thickness Tester with Probe for 7.62mm Gun Barrel.

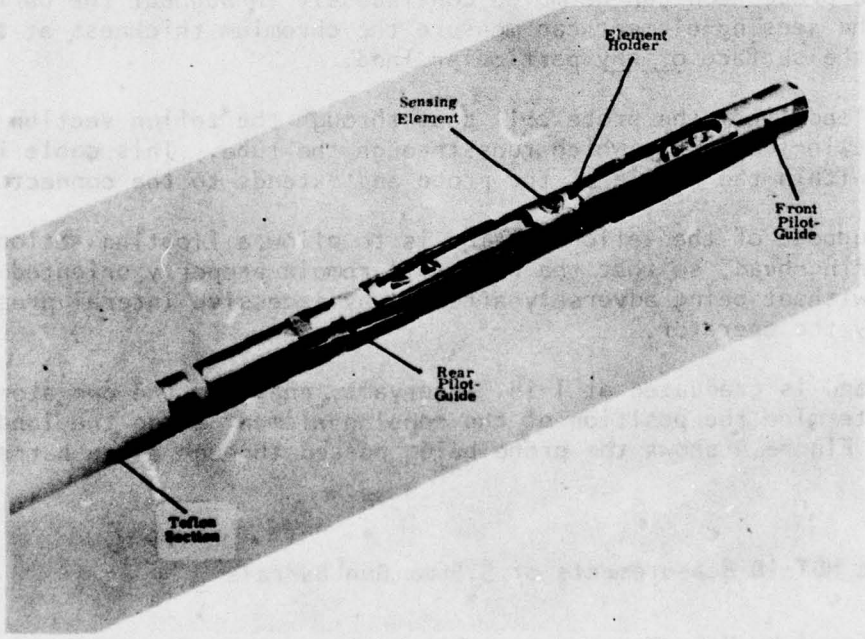

Figure 3. Close-Up of Probe for Dermitron Thickness Tester

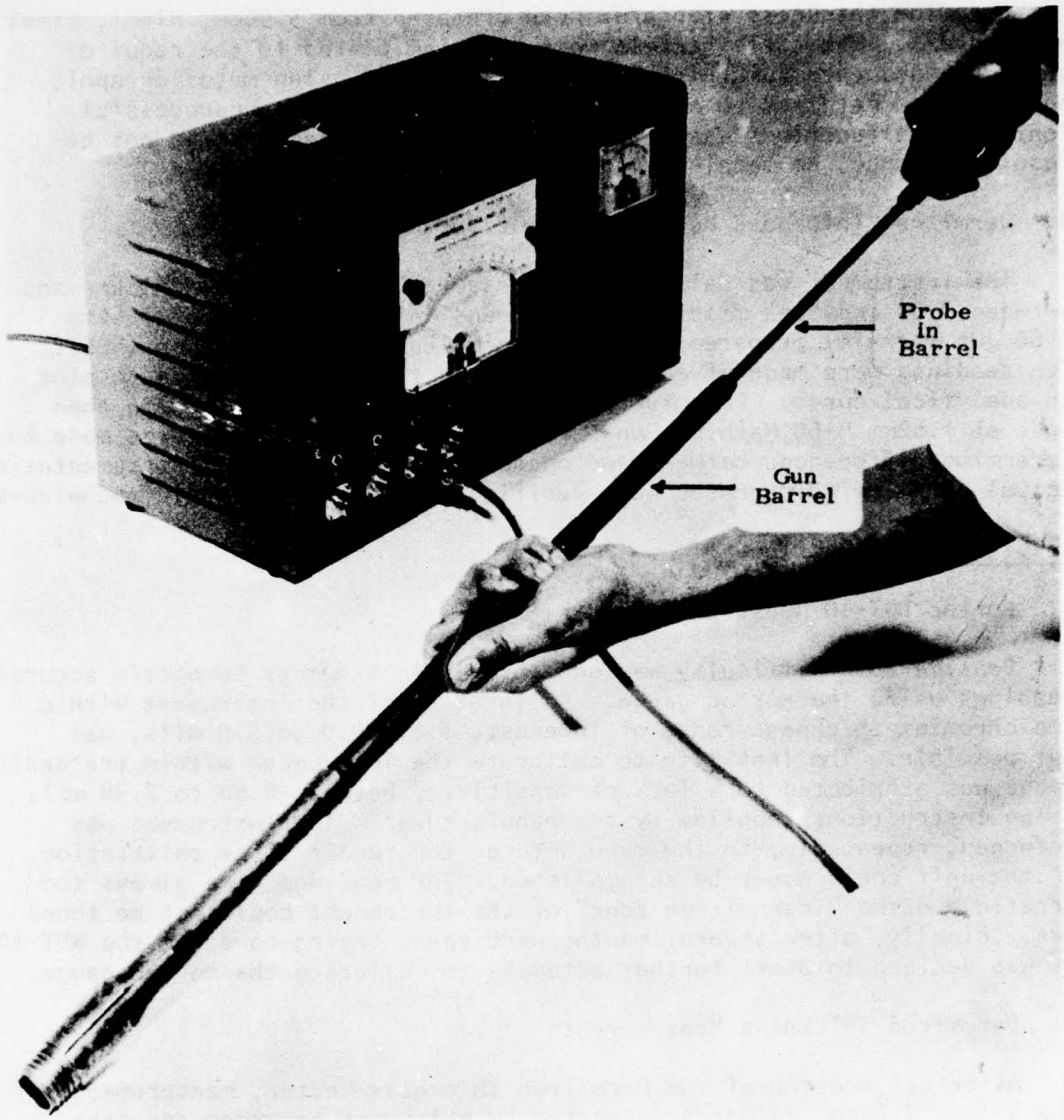

Figure 4. Dermitron Thickness Tester with Probe Inserted in a 7.62mm Gun Barrel.

Chromium thickness standards were prepared from 5.56mm, M16A1, steel gun barrels. The rifle barrels were chromium plated to the required thickness and chromium thicknesses were measured using metallographic techniques. Attempts to calibrate the instrument were unsuccessful. Continued malfunctions associated with the NDT-10 gauge could not be resolved, hence, no meaningful data could be recorded.

B. Dermitron Thickness Measurements of 7.62mm Gun Barrels

The instrument was calibrated to measure chromium plate thicknesses between 0.00 and 5.44 mils using specimens (4-in. sections of 7.62mm M-60 gun barrels) prepared by the National Bureau of Standards (NBS). Ten readings were made of each specimen and the data were used to plot an analytical curve. Chromium plate thickness measurements were then made of 7.62mm M-60 Machine Gun barrels. Measurements were also made to determine differences between two operators using the same instrumentation. Actual chromium thicknesses were verified using metallographic techniques.

Results and Discussion

A. Nortec NDT-10 Measurements

Considerable difficulty was encountered in attempts to obtain accurate readings using the Nortec gauge. Calibration of the instrument within the chromium thickness range of interest, i.e., 0.0 to 5.0 mils, was not possible. The inability to calibrate the instrument within the desired range was attributed to a lack of sensitivity between 0.98 to 2.38 mils using instructions supplied by the manufacturer. The instrument was returned, repeatedly, to the manufacturer for repair since calibration of the unit could never be accomplished. The readings were always too erratic and the "insensitive zone" of the instrument could not be tuned out. Finally, after several months were spent trying to debug the NDT-10, it was decided to abort further attempts to calibrate the Nortec gauge.

B. Dermitron Thickness Measurements

After calibration of the Dermitron Thickness Tester, measurements of the 4-in., 7.62mm standards, prepared by NBS, were recorded and are presented in Table 1. It is observed that the accuracy of the measurements ranged from -0.22 to +0.35 mils. These inaccuracies were scattered, i.e., the measurement errors were as large, in mils, for smaller plating thicknesses as they were for larger thicknesses. This is unusual since the sensitivity or accuracy of such an instrument is generally constant or varies in a consistent manner. When an instrument performs in the manner displayed by the Dermitron, either the circuitry is inadequate or manipulation of the probe by the operator causes the erroneous or highly-scattered recordings. Great care was taken to prevent the latter occurrence. The probe was designed to minimize extraneous sensitivity and the

TABLE 1. DERMITRON TEST DATA

Chromium Plate Standards (mils)	Dermitron Meter Readings	Average Dermitron Meter Readings*	Dermitron Readings (mils)	Deviation from Standard (mils)
0.00	0	0	-----	-----
0.80	26 - 34	29.2	0.70 - 1.02	-.10, +.22
1.25	36 - 42	39.1	1.10 - 1.40	-.15, +.15
2.30	54 - 63	58.0	2.08 - 2.65	-.22, +.35
4.30	82 - 87	84.9	4.10 - 4.45	-.20, +.15
5.44	0	100.0	-----	-----

*Average values based on 10 recordings

operator of the equipment exercised great caution to insure that the probe was handled in the same manner each time a measurement was taken. However, the circuitry was checked and it appears that the instrument is somewhat hypersensitive to operator handling when the probe is used to measure thicknesses of short-length (4-in.) standards.

An analytical curve (Fig. 5) was derived from Table 1. Chromium thickness measurements were then taken of a 7.62mm, M-60 gun barrel. Measurements were started 1-in. from the muzzle end and at 2-in. intervals for the first 11 inches. It was planned to limit the number of measurements to 2 readings at each location since this procedure would be more amenable to production. However, the recordings were too scattered. Two recordings of one chromium plate thickness point would indicate variances of 0.2 to 0.5 mils. Consequently, the number of readings at each location was increased to insure accuracy. Data from these measurements are presented in Table 2. Although the errors appear large, the recordings show good correlation with actual thickness measurements taken of the gun barrel. The chromium plate thicknesses are consistently larger than those measured metallographically. Recalibration of the instrument would make the recordings more accurate.

Measurements taken to observe differences between 2 operators using the same equipment are shown in Figure 6. It is observed that fairly good agreement between the two operators was achieved. Comparative

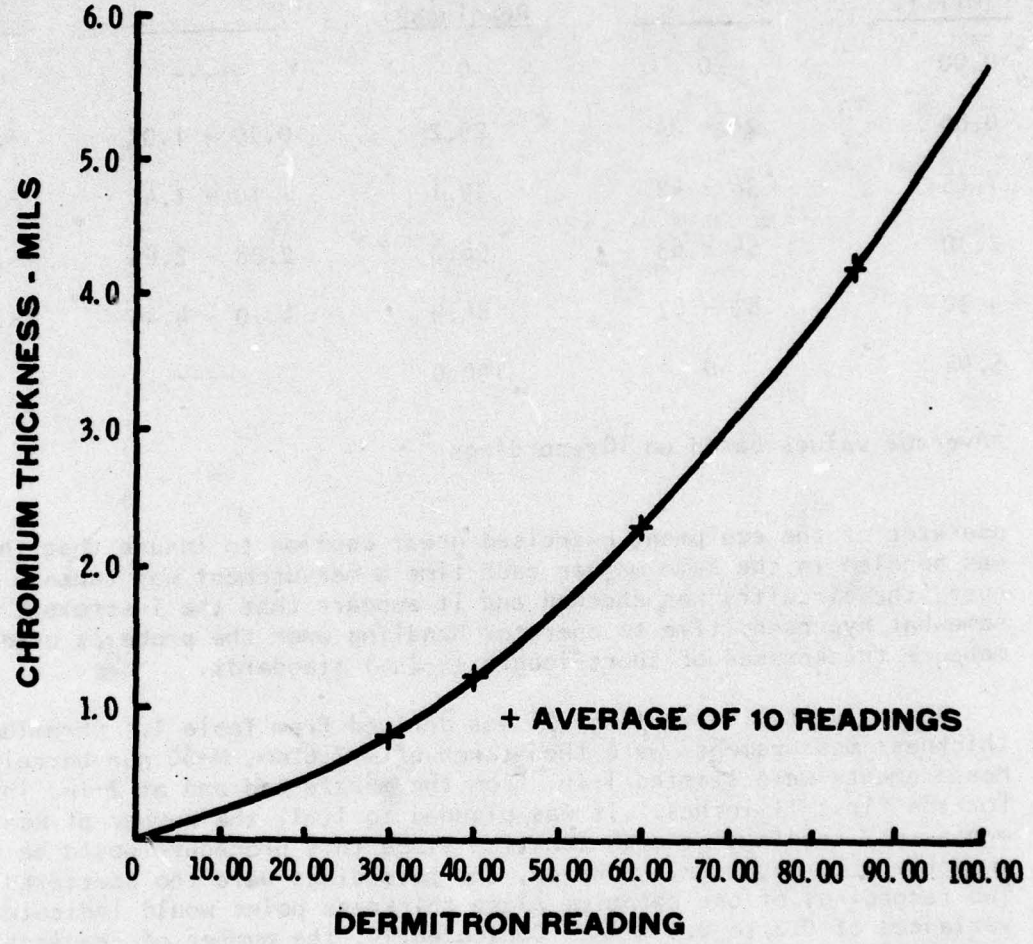

FIGURE 5. ANALYTICAL CURVE FOR THE DERMITRON THICKNESS TESTER USING THE 7.62MM PROBE.

TABLE 2. CHROMIUM THICKNESS MEASUREMENTS OF 7.62MM, M60 GUN BARREL

Distance from Muzzle End (ins)	Reference Metallographic Measurements (mils)	Dermitron Meter Readings	Dermitron Readings (mils)	Average Dermitron Readings (mils)	Deviation from Reference (mils)
1	2.45	61 - 66	2.52-2.90	2.75	+0.30
3	2.38	57 - 64	2.25-2.75	2.55	+0.17
5	2.20	52 - 62	1.95-2.60	2.41	+0.21
7	2.05	54 - 58	2.10-2.30	2.19	+0.14
9	1.90	52 - 58	1.95-2.30	2.12	+0.22
11	2.02	57 - 60	2.25-2.45	2.40	+0.38

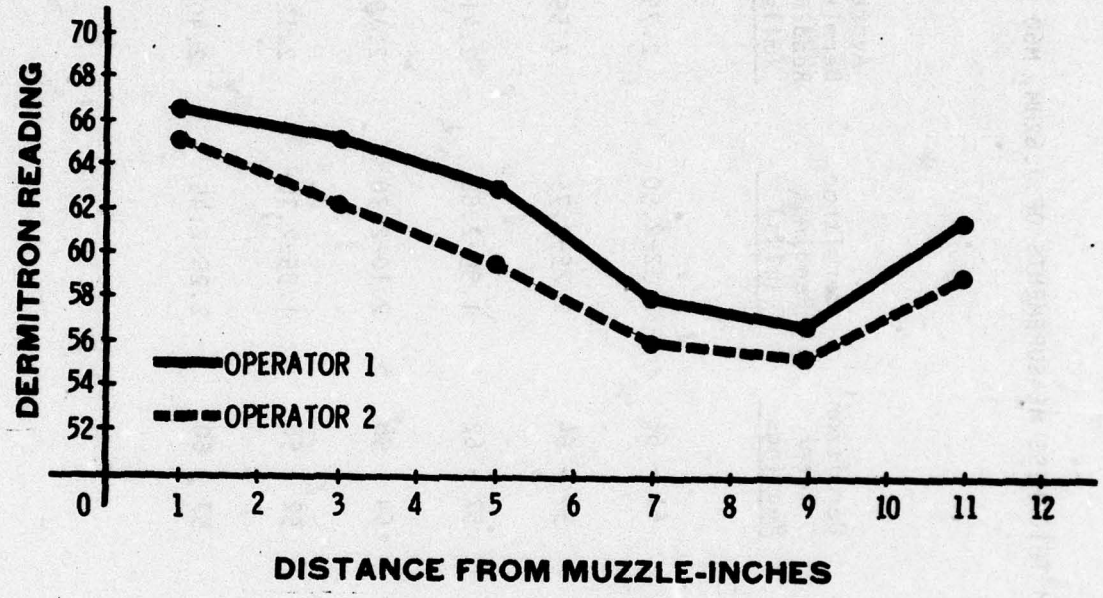

FIGURE 6. MEASUREMENT OF CHROMIUM PLATE THICKNESS IN 7.62MM, M60 GUN BARREL BY TWO OPERATORS.

recordings between operators varied from 0.08 to 0.19 mils.

Evaluation of the Dermitron Thickness Tester to determine chromium plate thicknesses in 7.62mm gun barrels resulted in the following observations.

a. The instrument recordings appear hypersensitive to manipulation of the probe within the gun tube by the operator. Consequently, a mechanical support/guide must be designed to keep the gun tube and the probe in perfect alignment. This should reduce the number of readings required for accurate data to 2 - 3 recordings at each point.

b. The tester reads the chromium thickness of only 1 land at a time. It is important, as stated previously, that the uniformity of the chromium deposit along the periphery of the bore be constant, consequently, at least 2 lands (approx. 180° apart) of the gun bore must be measured. This dictates that 2 readings at 6 points (12 recordings, min.) would be required to insure reliable data during NDT inspections of production gun barrels. This would not be unreasonable should the Dermitron Thickness Tester be implemented as an inspection tool. The primary objection would be directed to the calibration requirements of the instrument. The instrument must be calibrated at least 2 - 3 times during an 8-hour work shift. At the present time, approximately 1 hour is required for each calibration. However, with the use of automated recording/printout methods, the calibration time could be reduced to less than 15 minutes. Actual measurements of a production gun barrel could then be accomplished within 5 - 10 minutes after derivation of an analytical curve.

CONCLUSIONS

It is concluded that:

a. The chromium plate thicknesses of small caliber gun barrels can be determined nondestructively using Eddy Current testing methods.

b. The Nortec NDT-10 Eddy Current Tester is not sufficiently developed for use in the determination of chromium plate thicknesses on steel.

c. The Dermitron Thickness Tester is sufficiently accurate for the measurement of chromium plate thicknesses in 7.62mm gun barrels.

RECOMMENDATIONS

It is recommended that:

a. A mechanical support/guide to align gun tube and probe be designed to minimize erratic recordings caused by manual manipulation of the probe

as it passes through the standards and the gun barrels.

b. An automated recording/printout system be used in conjunction with the Dermitron Tester to make it a more useful and more easily calibrated production tool.

c. A swivel handle be designed to facilitate movement of the probe as it is passed through the gun tube.

d. Other probes (including different sizes and/or rifling configurations) be acquired and evaluated to expand the use of the Dermitron Thickness Tester.

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Report TR-EN-78-05, May 78, 18 p. incl. illus. tables, (AMS Code 5397-0M-6350) Unclassified report.

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Chromium-plate thicknesses of gun barrel bores are unjustifiably assumed since the air gauges used simply provide differences in bore-size readings before and after plating. The only means available to accurately determine plating thickness, including concentricity, is to use destructive methods to examine microspecimens representing cross sections of the gun barrel. The objective of this project was to make use of improved nondestructive testing methods to measure chromium plate thicknesses in small caliber gun barrels.

UNCLASSIFIED

1. Small Caliber Gun Tubes
2. Chromium Plate Thickness
3. Non-Destructive Testing (NDT)
4. Eddy Current Testing

Evaluation of improved NDT inspection methods resulted in the selection of two instruments using eddy current testing technology. The instruments, selected for comparative evaluation, were the Nortec NDT-10 and the Dermitron Thickness Tester. The Nortec NDT-10 Eddy Current Tester, used to measure 5.56mm gun tubes, could not be calibrated due to repeated malfunctions of the instrument; consequently, no meaningful data could be recorded. The Dermitron Thickness Tester, used to measure 7.62mm gun tubes, was calibrated and chromium thickness measurements were taken of an M-60 gun barrel. These measurements showed good correlation with actual thickness measurements of metallographic specimens taken of the gun barrel.

The accuracy and usefulness of the Dermitron would be improved by more frequent calibration and reduction of calibration time by using automated recording/printout methods. Recommendations to expand the use of eddy current testing methods for the determination of chromium plate thicknesses in small caliber gun barrels have been made.

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